another portion of the bladder; but if the entire resection of the bladder is indicated, the anastomosis with the two parts of the colon is all that can be done.

The same thing holds true in severe cases of tuberculosis rendering entire resection of the organ imperative, although, unfortunately, the renal lesions, which are so apt to exist at the same time, render permanent benefit unlikely.

In exstrophy, Pousson has advised, and Tuffier has executed, a cystorectal anastomosis; but the operation of Tuffier usually leads to a permanent cutaneous fistula. This is not the case with the intestinal anastomosis of the ureters, which obviates entirely this inconvenience, and which is certainly more satisfactory than the ingenious procedures of Segond. The author summarizes his views as follows:

(1) The anastomosis of the ureters with the intestine is an easy and a favorable operation. That it does not necessarily lead to a hydronephrosis due to contraction of the orifice of exit, nor to pyelo-nephritis due to ascending infection, is proved by his personal observations.

(2) The bilateral operation, successfully performed by Novaro upon dogs, can certainly be successfully performed upon man.

(3) The exit of urine into the intestine does not cause special inconvenience, and neither impairs digestion nor irritates the mucosa; the stools are somewhat more frequent, but not more so than normal micturition.

(4) The operation is a valuable recourse in certain cases where the more simple methods of intervention are inapplicable.

It is particularly indicated in complete resection of the bladder —cancer, tuberculosis, exstrophy—in fistulas of the ureter, and in wounds and ruptures of the organ, and in certain cases of ureteral calculus.

H. P. DE FOREST.

ON THE SURGERY AND PHYSIOLOGY OF THE SPLEEN.

THE demonstration was made by Zacaralla in 1549 that the human spleen could be successfully removed. Köberle, Péan, Credé, and others have also performed the operation upon the human subject.

As a result of these operations there was observed an increase in the lymphoid tissue in other parts of the body, as evidenced by an enlargement of the lymphatic nodules.

Some physiologists have shown that the spleen is a blood-forming organ (Gerlach, Funke); others claim that the red blood-cells are destroyed in this organ (Kölliker, Ecker). These discrepancies are due to the fact that the ratio of red cells to white cells is probably greater in the splenic artery than in the vein, and either the theory that white cells are formed or that red cells are destroyed in the spleen might be based upon this fact. Gibson reconciled these theories by claiming that in the spleen the colored corpuscles undergo disintegration, and that white corpuscles are formed which eventually become transformed into red cells.[1] The evolution of what little we know of the function of the spleen has been slow and fraught with much contradiction.

The surgery of this organ has scarcely begun. Forty years ago Küchler, of Darmstadt, ventured to remove an hypertrophic malarial spleen. His patient died, and he was sharply criticised by the medical societies of his day.[2] Adelmann endeavored to support Küchler, but the statistics upon the strength of which he made his decision were very meagre, and involved cases in which the spleen had been prolapsed through some abdominal wound. The only case at that time, which had been operated upon for organic disease, was a single case in which Quittenbaum, in 1826, had done splenectomy.

Vulpius, of Heidelberg, who has compiled an immense number of statistics upon this subject, and to whom is due the credit of all of the following figures, has shown that at the present time, out of more than one hundred cases of laparosplenectomy, the number of cures has been about 50 per cent.; and that the diseased spleen is no longer a *noli me tangere* for the knife of the surgeon.[3] He has reported five cases operated in Czerny's clinic,—two for leukæmia, and one each for enlarged wandering spleen, simple hypertrophic spleen, and necrosis of the spleen. The latter case developed a pleuritis with effusion on the left side, which became empyemic. This complication retarded the convalescence, but the patient was eventually cured, and the removal of the spleen caused no general disturbance.

---

[1] Landois: Lehrbuch der Physiologie des Menschen.

[2] König: Lehrbuch der speciellen Chirurgie.

[3] Vulpius: Beiträge zur Chirurgie und Physiologie der Milz; Beiträge zur klinische Chirurgie, Bd. XI, 1894.

The case of idiopathic hypertrophy of the spleen developed an interesting condition of the blood. The proportion of white to red cells had been normal, but on the day following the operation the ratio was 1 : 60. Gradually this excess of white cells subsided, and the ratio again became normal (1 : 500) at the end of four months.

Of these five cases, two died as a direct result of the operation. Both of these were pronounced cases of leukæmia. The hæmorrhagic diathesis in these cases was the cause of an overwhelming bleeding, which was so far beyond the control of the surgeon that these two cases sufficed to teach the Heidelberg clinic that the leukæmic spleen was not a subject for operation.

The two most satisfactory cases were those of hypertrophic spleen, for which there was no discoverable cause, and which, from the size and the general disturbances which they caused, were removed. These patients made a good recovery.

There have been reported twenty-eight cases of laparosplenectomy for leukæmic hypertrophy. Twenty-five of these died from the immediate effects of the operation. Twenty died from hæmorrhage during the first twelve hours after the operation, two of septic peritonitis, and one of shock. In two cases the cause of death is not stated, though hæmorrhage was the probable cause, because death took place within five hours after the operation. But three cases have survived. Franzolini's case was one of mild leukæmia with a moderately enlarged spleen, and was permanently cured, the blood being normal at the end of three months. Bardenheuer's patient died thirteen days after the operation of general prostration from the disease. The patient upon whom Burkhardt operated went eight months, and then died of weakness from the progress of the disease.

It is, therefore, evident that out of these twenty-eight cases but one cure is reported; and the diagnosis of this case must be looked upon with some doubt. The cases of Burkhardt and Bardenheuer have demonstrated that the operation can be carried out successfully in extreme cases of leukæmia with very large tumors, but that, even when the great danger of hæmorrhage has been overcome, the patients subsequently perish from the exhaustion of the disease. The conclusion which would be drawn from these facts is that extirpation of the spleen does not cure the disease, but that it is a disease of other tissues as well, and continues to exist when this organ is removed. It is, therefore, according to Vulpius, very probable that the observations of Franzolini are faulty.

The leukæmic tumor of the spleen is absolutely not to be operated upon in cases of advanced disease,—that is, when the blood-cell ratio is 1 : 50.

Only in cases in which there are but slight changes in the blood and when the tumor causes great inconvenience can operation enter into consideration. This, of course, would be very rare, for a very large spleen would be found with marked blood-changes. In no case, then, can the operation be hoped to do more than relieve the immediate symptoms arising from the physical presence of the tumor.

A second group of statistics include the cases of laparosplenectomy for malarial and idiopathic hypertrophy and wandering spleen. It is a fact that enlargement of the spleen is often the cause of its wandering.

In this group sixty-six cases can be found in the literature. Of these, twenty-six could be traced to malaria as the ætiological factor; while in twenty-one the hypertrophy had to be called idiopathic. In the remaining nineteen cases, the dislocation of the spleen was the cause which indicated operative treatment. Death resulted in twenty-four cases,—a mortality of 36.4 per cent. Eleven of the deaths occurred in cases of malarial and simple hypertrophic spleen, and only two in cases of wandering spleen. The last case was one of very large spleen; and in this and the other the patients died of peritonitis.

When cases of wandering spleen and cases of idiopathically enlarged spleen are classed together, the mortality of operation is 32.5 per cent. against 42.2 per cent. in malarial spleen. All of the cases which perished after operation for hypertrophic or wandering spleen were cases in which the tumor was of very large size. A study of these cases would show that the limit of safety is a tumor of 3000 grammes. Death followed from shock right after the operation in three cases, from exhaustion and sepsis in one case each, and from hæmorrhage in seven cases.

The case is quite different with malarial tumors, in which there seems to be no relation between the size of the tumor and the mortality, and in which many of the cured cases were those in which the tumor was very large.

Of the eleven cases of death, two were from unknown causes; one each from shock, collapse, and peritonitis; one from nephritis, which resulted in death a month after the operation; and five from hæmorrhage.

The statistics, therefore, stand as follows: mortality in laparosplenectomy for non-leukæmic enlargement and for wandering spleen 20 per cent., and for malarial spleen 40 per cent. The mortality in cases of echinococcus of the spleen is 40 per cent. Four cases of sarcomatous spleen have been extirpated. One case died at once, and the other three perished from recurrence.

The three attempts to extirpate the congested spleen were unsuccessful, as was an attempt to remove an amyloid spleen. Such attempts as this are to be discouraged because these conditions are associated with general disease.

Of very great interest is Lane's attempt to save two patients from bleeding to death from traumatic rupture of the spleen. Though both cases were unsuccessful, the operation, according to Vulpius, is eminently justified.

Burke[1] has reported a case operated upon for tuberculosis.

The cases of laparosplenectomy in the literature amount to 117.

---

[1] Lawrence Burke: Dublin Journal, LXXXVII, p. 540, June.

Of these 59 (50.4 per cent.) were cured, and 58 (49.6 per cent.) died. When from these statistics are excluded cases which, according to Vulpius, should not have been operated upon,—namely, leukæmic, chronically congested, and amyloid spleens,—85 cases remain. Of these 85 29 died, which gives a result of two-thirds of the cases cured.

The following is a table of the cases in the literature as collected by Vulpius:

	Disease.	No. of Cases.	Cured.	Died.
1	Leukæmia	28	3 = 10.7 per cent.	25 = 89.3 per cent.
2	Hypertrophy (simple, malarial, and wandering spleen).	66	42 = 63.6 "	24 = 36.4 "
	(Malarial hypertrophy alone.)	(26)	(15 = 57.7 ")	(11 = 42.2 ")
3	Echinococcus	5	3 = 60 "	2 = 40 "
4	Simple cysts	4	4 = 100 "	
5	Sarcoma	4	3 = 75 "	1 = 25 "
6	Abscess	3	3 = 100 "	
7	Chronic congestion . .	3	. . . .	3 = 100 "
8	Amyloid degeneration.	1	. . . .	1 = 100 "
9	Syphilis	1	1 = 100 per cent.	
10	Rupture	2	. . . .	2 = 100 "
	Total	117	59 = 50.4 per cent.	58 = 49.6 per cent.
	Total after deducting 1, 7, and 8.	85	56 = 65.9 per cent.	29 = 34.1 per cent.

In two or three of these cases there was observed multiple enlargement of lymphatic nodules; about the same number developed goitre; and in another case morbus basedowii occurred. These changes have been observed so rarely that they need not be taken into account with the operation of splenectomy. The lymphatics have been watched very closely after many operations, and no sign of change discovered. The changes in the blood are much more constant and of much greater value in these cases. There are on record twenty-nine cases of laparo-splenectomy in which investigation of the blood was made after the operation; nineteen of these are of especial value, because in these an exact record of the condition of the blood was made before the operation.

A diminution of the white blood-corpuscles, and therewith a return to the normal conditions, were observed in two cases. One was in Franzolini's case of doubtful leukæmia, and the other was in a case of Albert's, in which the red blood-corpuscles were so reduced that there was a relative leucocytosis.

Three authors have reported diminution of the number of red blood-corpuscles in patients suffering from malaria. How much this disease in itself, or in connection with the bloody operation, has to do with the changes in the blood cannot be positively determined, because of the small number of cases reported.

Vulpius regards of very great importance the fact that eleven observations showed that after the operation there was a more or less rapid and pronounced increase in the number of leucocytes. In two cases this could not be assigned alone to the splenectomy, for the patients were suffering from leukæmia, which continued to progress,—in one case with very great rapidity. The relation of these blood-changes to the operation corroborates the observations of Zesas, based upon experiments with animals, and showing the relation of the spleen to the formation of the blood. Hereafter every operation should show, by careful examinations of the blood, whether the multiplication of leucocytes is invariably the rule or is simply a coincidence in these cases.

The following is Vulpius's table of the cases of laparosplenectomy in which an examination of the blood has been reported, showing the ratio between white and red cells:

	Case.	Before Operation.	After Operation.
1.	Leukæmia	1 : 74	Normal after three months.
2.	Leukæmia	1 : 105	1 : 50 after six months.
3.	Leukæmia	. . . . . .	1 : 7, 1 : 5, 1 : 3 thirteen days after the operation.
4.	Wandering spleen	Normal	Normal.

	Case.	Before Operation.	After Operation.
5.	Wandering spleen	1,700,000 red; 26,000 white: ratio 1 : 65	Three weeks after operation, 3,600,000 red; 12,000 white: ratio 1 : 300.
6.	Wandering spleen	1 : 400	1 : 160.
7.	Wandering spleen	Normal	Normal.
8.	Wandering spleen	1 : 240	Two months after operation, 1 : 240.
9.	Wandering spleen	1 : 250	Soon after operation, 1 : 150.
10.	Wandering spleen	Normal	Normal.
11.	Wandering spleen	. . . . . .	Increase of white cells, 7 x; rapid improvement.
12.	Wandering spleen	. . . . . .	Fourteen days after, rapid appearance of leucocytes.
13.	Hypertrophy	Normal	Normal.
14.	Hypertrophy	1 : 200	Unchanged.
15.	Hypertrophy	4,570,000 red 8000 white ratio 1 : 570	Two days after, 1 : 62. Five months after, normal.
16.	. . . .	1 : 430	1 : 425.
17.	Hypertrophy	. . . . . .	After six months, slight increase of white corpuscles.
18.	Malaria	Normal	Passing diminution of red corpuscles.
19.	Malaria	Normal	Normal.
20.	Malaria	Normal	Normal.
21.	Malaria	1 : 400	Unchanged.
22.	Malaria	. . . . . .	Passing diminution of red corpuscles.
23.	Malaria	. . . . . .	Passing diminution of red corpuscles.
24.	Necrosis	. . . . . .	After three weeks, 1 : 60. After four months, normal.
25.	Echinococcus	Normal	Normal.
26.	Cyst	. . . . . .	After some weeks, 1 : 200; white increased, red diminished. After two years, slight increase of white.
27.	Cyst	. . . . . .	After eight days, increase of white. After two months, 1 : 3 or 4. After four and a half months, normal.
28.	Sarcoma	1 : 500	After six weeks, red diminished, white increased; ratio 1 : 100.
29.	Sarcoma	. . . . . .	Normal.

From these figures it may be concluded that the leukæmic spleen is not to be extirpated; that the operation has little possible chance of doing any good; and even if the patient survives, the disease is apt to continue even with increased severity.

So much, then, for the surgery of the spleen. As a result of these observations, Vulpius has been able to draw some conclusions as to the physiology of that organ, and these he embodies in some general observations upon the subject.

It was Vesalius who first regarded the spleen as a blood-forming organ, and this opinion has been shared, with certain modifications, by all physiologists.

To Virchow is due the credit of first discovering the disease of leukæmia and showing its relation to the spleen, and thereby demonstrating the physiological relation between the spleen and the blood. He believed that the white blood-cells can become converted into red cells, but whether this change takes place in the spleen he does not presume to say.

Funke believes that this transformation takes place in the spleen. Kölliker has observed in the pulp of the spleen of young animals numerous mononuclear small cells of such a yellow color that they could scarcely be distinguished from red blood-cells. Freyer is of the opinion that red blood-cells originate in the spleen.

Lolwit has discovered erythroblasts, non-hæmoglobic blood-cells, in large numbers in the spleen, where he believes they become transformed into nucleated red blood-cells.

Microscopic study of the spleen shows also that it is the seat of regressive metamorphosis. Mosler has called attention to masses of red blood-cells which were evidently in a state of degeneration. Virchow discovered large cells containing blood-corpuscles which tended to degeneration and to undergo fatty changes. Kölliker often found these in the spleen and also in the blood. They are large nucleated structureless cells which are possessed of amœboid movements and enclose the degenerated cells. Gerlach and Schaffner regarded these as mother-cells of the red corpuscles. This was shown to be false by Kusnezoff and Gaddi, who isolated the cells from the splenic pulp and observed their phagocytic action upon the warmed microscopic stage. The liberated pigment matter from red cells could be disposed of by being converted into new cells or by being cast off from the body. Perhaps the pale color of the bile and fæces in splenectomized animals is due to the discontinuation of pigment-formation in the spleen. Chemical examination of the spleen shows it to contain an excess of iron, and the results of retrogressive metamorphosis in the form of such albuminous bodies as leucin, tyrosin, etc., are also present.

A further source of information is the study of the blood, microscopically and chemically, before and after its passage through the organ. Though this may seem to be very valuable and important, it is with difficulty carried out to its full extent. Flügge has thus examined the blood of the hepatic veins and artery and portal vein to discover in this manner the function of the liver, and has concluded that a comparative examination of the afferent and efferent blood cannot reveal the function of the liver or any other organ.

Notwithstanding this radical view, many careful observations of this character have been made, which Vulpius thinks must have some value. The first investigations in this line were those of Wiss (1847) and Béclard (1848), who analyzed the blood of the jugular vein and mixed blood from the venæ mesaraicæ and lienalis, and found comparatively less blood-cell substance in the splenic vein.

Tarchanoff and Swaen found the splenic veins poorer in white blood-cells than the arteries. Otto has shown that in venous blood there is a larger amount of cellular elements than in arterial blood; as especially is this the case in chronic congestion.

Schwartz has concluded that the colorless blood-cells have a degenerating as well as regenerating effect upon the hæmoglobin. Glass has also found that blood pigment is both destroyed and formed in the spleen.

Many similar observations have been made, but always with more or less discrepancy of conclusion. From these observations it would seem that the white elements in the veins are sometimes increased, sometimes diminished; and the percentage of hæmoglobin also fluctuates above and below the normal. Evidently the spleen performs the two functions,—the production and destruction of hæmoglobin.

Neumann's experiments failed to show any increase in the activity of the function of the spleen after loss of blood. On the other hand, Bizzozero and Salvioli obtained a very different result. They observed that in dogs and guinea-pigs venesection was followed by a considerable swelling of the spleen, and the appearance of numerous nucleated red blood-cells in the parenchyma and in the marrow of the bones, while these young forms were very rarely to be found in the circulating blood. These observers concluded that the spleen of adult mammals has a reparative function in acute anæmia.

Foa rendered dogs and guinea-pigs anæmic by venesection, and found that the spleen became swollen, the pulp red and soft and rich in nucleated red blood-corpuscles. He made the observations in the human subject that a man and a woman who had died from carcinomatous cachexia contained spleens which were swollen and contained nucleated red blood-cells, which were not found in the intravascular blood.

Braunschweig, Freiberg, and Eliasberg have found that venesection in cats is followed by a rapid swelling of the spleen.

Mya, Popoff, and Eliasberg have found these changes in the spleen when the hæmoglobin of the blood has been disintegrated by poisonous substances.

Assolante, in 1801, made the observation that the blood of splenectomized animals was especially watery, though Bardeleben was not able to discover any blood-changes in dogs thus treated. Schiff also disputed that the spleen had anything to do with the number of red or white corpuscles.

Simon and Heger experimented upon cats, and found in one case no pronounced change in the blood three weeks after extirpation of the spleen. In a second case, however, there was a considerable increase of white cells at the end of eight weeks. Virchow's observations corresponded with this latter report. Mosler found the same blood-changes in a number of dogs experimented upon.

Schindeler and Maggiorani concluded from their studies that extirpation of the spleen caused the blood to become of less specific weight, to contain a smaller amount of fibrin and albumen, less blood-coloring matter and less iron.

Malassez found that in a splenectomized dog the number of blood-cells and the percentage of hæmoglobin diminished during the first days, but after a month the percentage increased to above the normal.

Tizzoni observed a diminution of the hæmoglobin in dogs after extirpation of the spleen, which in the case of young animals quickly returned to the normal percentage. In older dogs a much longer time was required for this change.

Experiments were made by Pouchet on all sorts of animals,—turbots, doves, puppies, and cats,—and no physiological connection between the spleen and the blood was found.

The investigations made during the last decade are of much more value than all of these previous observations. Winogradoff has had the opportunity of observing three splenectomized dogs for a long period of time. He observed a diminution of the number of red blood-cells and of the hæmoglobin, and an increase of the colorless cells in two cases; in a third case the number of white cells was increased. Tauber found a diminution of red cells and an invariably present increase in the number of white cells in his experiments upon various animals. Zesas kept rabbits alive for a considerable length of time after extirpation of the spleen and made frequent observations of the blood. Four weeks after the operation the red cells had decidedly diminished in number, and were of a darker color than normal. The white cells had increased in number and were larger in size than normal. This increase of the latter continued till the tenth week, at which time the blood was poor in red cells and richest in white corpuscles. A diminution in the number of white cells then began, which continued to progress, though much more slowly than the increase had advanced. Not till the end of six months was the blood again normal. Zesas concluded that the white cells were converted into red cells in the spleen, though he did not claim that the spleen was the only organ in which this change took place.

Grigorescu reached the same conclusion. He found that three hours after a meal the blood showed 5,970,000 red cells to 7000 white cells. At the same time and under the same circumstances the splenectomized animal's blood showed 5,465,000 red to 29,000 white cells to the cubic millimetre, a diminution of 1 : 654 to 1 : 225.

Vulpius has called attention to the fact that when the spleen is congested, either by natural or artificial means, the blood is then found to contain the maximum number of red cells and the minimum of white. This, with the above experiments, gives ground for the hypothesis that the spleen is a blood-forming organ, and that in this organ the white cells are transformed into red.

The following figures show the number of erythrocytes in the blood of the rabbit. Malassez found respectively 4,300,000, 4,540,000, and 4,160,000; Stölzing, 4,866,000; and Hühnerfauth, 5,385,000, 7,206,000, and 5,304,000. The average of these figures corresponds with the figures of Otto, 5,100,000. The number of colorless corpuscles in the vena jugularis of the rabbit Hühnerfauth found in three different observations to be 8100, 8700, and 18,600 respectively,—average, 11,800. Malassez counted 18,000,000 red cells to the cubic millimetre of goat's blood. Landois found a few more than half this number in the blood of the kid.

With these as control figures at hand, Vulpius made a series of observations upon these animals. He found that in the blood of a year-old rabbit the red cells varied between 4,200,000 and 6,500,000, which corresponds with the above figures. His estimation of the white cells corresponded also with the above figures. This number he found to fluctuate between 7200 and 15,400, or an average of 11,400, white to red,—1 : 450. The blood of a six-months old goat showed 16,000,000 and 20,000,000 of red cells per cubic millimetre, or an average of 18,000,000; and 15,000 to 30,000 white cells, or an average of 23,500,—ratio of white to red 1 : 800.

Animals were then operated upon whose blood had been carefully examined. The operations upon the rabbits were performed without narcosis, those upon goats were done under the influence of ether. Most of the animals thus operated upon made good recoveries. Several of the rabbits died of tuberculosis one to three weeks after the operation. Cheesy foci were found in many organs and at the seat of the ligature of the pedicle.

The following is a table of the observations made by Vulpius upon the animals upon which he operated:

RABBIT 1.

August 21, 1893.	Blood: 5,050,000 red, 13,000 white.
24, 1893.	Laparosplenectomy without loss of blood.
28, 1893.	Animal quite lively. Blood: 4,700,000 red, 22,300 white.
29, 1893.	Blood: 4,730,000 red, 22,000 white.
September 1, 1893.	Animal decidedly sick.
2, 1893.	Died at noon. No sign of peritonitis. Tubercular nodules in the liver, and a large tubercular focus at the stump of the pedicle.

RABBIT 2.

August 22, 1893.	Blood: 5,300,000 red, 11,800 white.
24, 1893.	Laparosplenectomy without loss of blood.
25, 1893.	Animal very lively. Blood: 4,800,000 red, 12,300 white.
September 14, 1893.	Blood: 4,800,000 red, 22,400 white.
October 3, 1893.	" 5,000,000 " 21,500 "
7, 1893.	" 5,200,000 " 21,500 "
26, 1893.	" 5,150,000 " 16,000 "

The animal continued to survive in perfect health.

RABBIT 3.

August 25, 1893.	Blood: 5,110,000 red, 13,200 white.
26, 1893.	Laparosplenectomy without loss of blood.
27, 1893.	Animal very lively.
30, 1893.	" lazy.
31, 1893.	Died at noon. The blood from the heart showed 4,730,000 red, 18,830 white.

Rabbit 4.

August 23, 1893.	Blood: 5,250,000 red, 9,700 white.
25, 1893.	“ 5,170,000 “ 12,300 “
26, 1893.	Laparosplenectomy without loss of blood. Within a few hours the animal was well and lively.
September 14, 1893.	Blood: 4,800,000 red, 23,800 white.
October 15, 1893.	“ 5,300,000 “ 18,400 “
30, 1893.	“ 5,200,000 “ 12,300 “

The animal continued to live in perfect health.

Rabbit 5.

August 23, 1893.	Blood: 4,900,000 red, 10,500 white.
26, 1893.	Laparosplenectomy without loss of blood.
28, 1893.	Blood: 4,600,000 red, 13,000 white.
September 4, 1893.	“ 4,200,000 “ 21,000 “
15, 1893.	Animal died. No autopsy.

Goat (weight 9.5 kilogrammes).

August 21, 1893.	Blood: 19,100,000 red, 22,500 white.
26, 1893.	Laparosplenectomy. The spleen contained 50 grains of blood. The animal recovered rapidly from the operation.
28, 1893.	Animal perfectly well.
September 7, 1893.	Blood: 16,000,000 red, 33,200 white.
7, 1893.	“ 18,000,000 “ 36,000 “
25, 1893.	“ 18,800,000 “ 31,000 “
October 13, 1893.	“ 18,200,000 “ 21,500 “
14, 1893.	“ 18,000,000 “ 24,600 “
28, 1893.	“ 19,000,000 “ 24,000 “

A combination of the results obtained in the various experiments upon rabbits gives a curve which shows a rapid increase of more than 100 per cent. in the leucocytes within nineteen days after the operation. From this high point the curve gradually sinks till it reaches the normal average on the sixty-fifth day. This curve corresponds with the observations of Zesas,—a rapid increase in leucocytes, and a gradual decline after splenectomy.

The same changes took place in the blood of the goat. The number of leucocytes rapidly increased till on the twelfth day it had arisen 30 per cent. From this point it gradually declined to a subnormal point on the forty-eighth day, from which it immediately arose to normal, and continued in that line.

The diminution in the number of red cells was not so marked. During the first few days it sank to 80 per cent. of the normal number. This occurred, in the case of the goat, by the second day; and with the rabbits, by the ninth day. From these minimum points it gradually increased, reaching normal on the thirtieth or fortieth day, and going slightly above normal during the few following days.

From these experiments Vulpius concluded that rabbits and goats bore extirpation of the spleen well; that an absolute leucocytosis which reached a degree in which the white cells were doubled in number, the number of red cells diminished not more than 20 per cent., and that both of these changes subsided to normal.

These experiments upon animals are chiefly of physiological importance, and have a practical bearing upon those cases in which the human spleen has to be extirpated for traumatism. Unfortunately, no record of blood analysis is accessible in these cases which have thus far been operated upon. In the other cases of human laparosplenectomy neither the general system nor the spleen of the patient was in a normal condition, and so cannot be compared with these animal experiments. This condition was nearest approached in a case of cystic spleen in which the blood-cell ratio sank to 1 : 200 after operation, due to an increase of white and a diminution of red cells.

Of especial interest is Credé's case, of a patient who, after the operation, became very pallid and feeble, and four weeks later was scarcely able to walk. One week after the operation there was a very evident increase of white and diminution of red cells in the blood. This change reached its maximum after two months, when the ratio was 1 : 3.5. Four and one-half months later the blood had become normal.

Czerny's case, operated upon for necrosis of the spleen, and Requer's case, of rupture of the spleen, cannot be introduced here, because of the changes in the blood due to the traumatic anæmia.

It may be remarked, however, that after these patients had recovered from their anæmia, there still existed an increase of white cells, which in the first case disappeared after four months, but which in the second case was still present at the end of seven months.

The cases of wandering spleen have little physiological value, because the so-called idiopathic wandering spleen is a thing of the greatest rarity, and is usually caused by hypertrophy. In three cases no blood-changes were found, but in two cases there was an increase of white cells. One of these latter had a blood-cell ratio of 1 : 160, the other 1 : 7.

Leucocytosis, which had existed before the operation, was observed in two other cases after operation. In Linfors's case, it continued to progress; but in Turetta's case it remained stationary.

After the extirpation of simple hypertrophic spleens much the same results have been obtained. In two cases increase of white cells was observed. In one of these cases (Péan) the ratio became 1 : 200; in the other (Czerny case) 1 : 62, without any evident change in this number of erythrocytes. The return to a normal condition took five months. In a case of Burkhardt's an excess of white cells, which existed before, was unchanged by the operation.

Examinations of the blood after the removal of three malarial spleens were negative. There were slight changes in three other cases, in one of which the number of red cells was diminished.

A case of lymphosarcoma, from which Kocher removed the spleen, showed a diminution in the number of red cells six weeks after the operation, and an increase in the number of white cells. Fritch observed no change in the blood of a similar case.

These differences in observations must have some physiological cause, and Vulpius has sought for it in the vicarious assumption of the function of the spleen by other organs. There must be some tissue in the body capable of performing the function of the spleen, or else there must be a new development of spleen-tissue after the extirpation of that organ, or an hypertrophy of some remaining splenic tissue. Peyrani refuted this last hypothesis by partially removing the spleen of a guinea-pig. The remaining portion did not become hypertrophied.

As there is no splenic development after the total removal of the human spleen, the vicarious hypertrophy of an accessory spleen may be considered. Such organs have been found not only in animals, especially in dogs, but are frequently met with in the human subject. When present, they have been found one or more within the ligamentum gastrolienale. They are of a roundish form, without a hilus, and the size of a bean or hazelnut, or larger.

Rosenmüller saw among 400 cadavers in North Germany one accessory spleen the size of a walnut. In Southern Europe he found this anomaly in five out of eighty cases.

Giesker confirmed the observation of Dupuytren, that this condition is common in young persons, and especially in fœtuses.

It is, therefore, very probable that these accessory organs can assume the function of the extirpated spleen. Unfortunately, the opportunity has never been afforded of making an autopsy upon a person who had survived the operation of splenectomy.

The appearance of secondary splenic nodules has been repeatedly observed and described as early as by Malpighi, and later by Meyer, 1842, who claimed that the new organ could reach the size of the normal spleen. Tizzoni saw among a large number of splenectomized animals a formation of numerous nodules upon the omentum, which had the appearance of splenic tissue. Kostjurin saw nodules the size of beans scattered over the greater omentum which had the structure of splenic tissue. Griffini saw the same thing also in a case of hypertrophy of the spleen. Eternod saw a splenic nodule on the omentum of a young fox, but no accessory spleen was present.

Mosler has made microscopic examinations of such tumors found in a dog whose spleen had been removed, and found what he called "hæmorrhagic teleangiectatic lymphoma,"—that is, a tumor having the gross appearances of splenic structure, but under the microscope being something quite different.

None of these observations having been made in man, the thyroid gland, the lymph-nodules, and the bone-marrow have been looked to as performing the function of the extirpated spleen.

Bardeleben has simultaneously removed the thyroid and spleen from dogs and cats, always with fatal results. A dog in which he did the operation in two stages recovered. Zesas made the same experiments, and regarded the thyroid as the most important associate organ to the spleen. Tauber was able to save animals with both organs extirpated simultaneously or at two sittings, and claimed that in ten out of every fifteen animals upon which he operated the thyroid was either missing or of insignificant size. Ughetti and Mattei showed that rabbits survived extirpation of both spleen and thyroid.

In the case of the human subject it is well known that the thyroid cannot be removed without causing very great harm.

Hyperplasia of the thyroid following splenectomy has been observed in only three cases. Credé noticed a painful swelling of the whole thyroid four weeks after the operation, which lasted in a milder degree for four months. As the marked leucocytosis subsided the gland also improved. A woman operated upon by Lählein developed a small, painful tumor of the thyroid, twelve days after the operation, which did not reach the size of an egg. Ceci has also reported a similar case.

The rarity of this complication, its timely subsidence, and the result of experiments upon animals would tend to preclude the hypothesis that the thyroid and the spleen have the same function. These rare instances of swelling of the gland may be accounted for upon the ground of congestion or blood-changes.

Swelling of the mesenteric and retroperitoneal lymph-nodules has been repeatedly observed in animals whose spleens have been cut out.

Pouchet has removed the spleen from animals which have no lymph-nodules, tritons, for example, without causing the death of the animal.

Zesas found at the autopsy on spleenless rabbits swelling of the bronchial and mesenteric lymphatics. These enlargements were noticeable one week after the operation, were pronounced after four to seventeen weeks, and at the end of six months had quite disappeared.

Winogradoff, Tizzoni, and Gibson examined these enlarged nodules found in spleenless animals, and found in the distended lymph-spaces between the follicles and follicular septa and in the peripheral sinuses, nucleated red blood-cells, just as in the bone-marrow.

In none of the animals operated upon by Vulpius was there any enlargement of lymph-nodules, neither in the animals which died soon after the operation nor in those which were killed at the end of five months.

Diffuse enlargement of lymphatics has been observed in man after the operation. Czerny saw these changes during convalescence in a woman operated upon for wandering spleen two weeks after the operation of the inguinal and cervical glands, which swelling disappeared after three months. In this case no blood-changes were discovered as a result of the operation. A case operated upon by Kocher for sarcoma showed an enlargement of the lymph-glands simultaneous with a leucocytosis. Lennander observed enlarged lymphatics some time after the operation. The enlargement was but slight, and could not be associated with the operation. Finally, Riegner has reported a case of extensive lymphatic enlargement which appeared in the groin four weeks after the removal of a ruptured spleen, extended over the whole body, and did not disappear till after seven months.

On the other hand, a large number of cases was associated with no such complication.

Pouchet has shown that fish, which have no bone-marrow, do not suffer from removal of the spleen.

Mosler found in a dog, ten months after splenectomy, that the bone-marrow was red and dense, as it is in leukæmia, whereas six weeks after operation it had been normal. Similar observations were made by Tizzoni, Winogradoff, Kostjurin, and Freiberg, who regarded the change as due to functional hyperæmia, and increased activity of the marrow in the sense of red blood-cell formation by the division of the nucleated red formative cells.

There has been scarcely any study of the bone-marrow made after extirpation of the human spleen. Patients have complained of pain in the extremities, which has been attributed to changes going on in the marrow of the long bones.

Riegner made an autopsy four weeks after removal of a ruptured spleen. The patient had lost much blood, and the changes discovered in the marrow had no very valuable significance.

If it is a fact that the spleen is one of the blood-forming organs, the removal of this organ associated with excessive hæmorrhage must cause a very great disturbance to the general system. When this does not result, it must be presumed that there are associate organs which take on an increased activity. If this last does not occur to a high degree in animals possessing spleens, and which have been rendered artificially anæmic, the hæmatopoietic function of the spleen is questionable.

Exact investigations in this line are not numerous. Malassez and Pouchet saw that the blood after venesection was the same in animals with as in those without spleens. Korn experimented upon sound and miltless pigeons. Four weeks after the splenectomy he bled these birds to prove whether there was any difference in their resisting powers as compared with the sound birds. He was not able to distinguish any difference.

On the other hand, Eliasberg, Grünberg, and Freiberg observed enlargement and redness of the lymphatics, reddening of the bone-marrow, richness of the same in nucleated red blood-cells when, in addition to extirpation of the spleen, a venesection was done.

Be these observations of as much importance as they will, the facts stand that patients whose spleens had been removed have been reduced to an extreme degree of anæmia and made a good recovery.

One of Czerny's patients lost much blood, so that the number of red cells was reduced 33 per cent. The loss of blood was about 2.5 per cent. of the body weight, and at the end of two months the blood had not yet reached its normal state.

Hühnerfauth, Lyon, and Maydl have found that in healthy men and animals a loss of blood equal to 3 to 4 per cent. of the body-weight is restored in thirty days.

Vulpius has arrived at the following general conclusions concerning the physiology of the spleen :

(1) Histological study of the normal splenic tissue shows the possibility but not the certainty of the entrance of colorless cells in the circulation from the spleen. It is evident that the red cells undergo disintegration in the spleen, but there is no ground for assuming that they are formed in the spleen.

(2) Comparison of the blood of the splenic artery and vein shows no positive difference.

(3) In acute general anæmia the spleen shows signs of increased activity.

(4) Removal of the spleen causes a transient decrease in the number of red, and increase in the number of white, blood-cells.

(5) The thyroid gland has no vicarious relation to the spleen.

(6) The lymph-nodules and the bone-marrow acquire an increased blood-forming activity after extirpation of the spleen.

(7) The regeneration of blood is retarded after hæmorrhage in persons without spleens.

These conclusions, though contradicting certain accepted teachings, offer little that is new, but are of value in that they are based upon accurate scientific data, and corroborate much that has already been done. Unfortunately, our knowledge of the physiology of the spleen is still left in a state of confusion.

The surgery of that organ is on a more established basis. We know that in the treatment of the operable splenic tumors the ordinary surgical and mechanical principles come into play. In the case of the leukæmic tumor, at least, this is not the case. Here we have to deal with a tumor which is but an incidental complication of a fatal general disease. Something more than the mechanics of surgery must be brought to bear in this case. This is not for those gentlemen to treat who, in the fulness of their operative zeal, would extirpate whatever abdominal tumor is removable. The examination of the blood and a study of statistics are matters of prime importance.

JAMES P. WARBASSE.